

# **Tides and Shelf Waves of Tidal Origin in the Bering and Okhotsk Seas**

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## **LONG-TERM GOAL(S)**

Our goal is to delineate regions of enhanced tidal currents in the Bering and Okhotsk Seas.

## **SCIENTIFIC/TECHNICAL OBJECTIVES**

- 1) Use two-dimensional coupled ocean-ice models with a horizontal grid-size in the range of 10 km to 600 m to investigate tidal motion in the Bering and Okhotsk Seas (BOS).
- 2) Use three-dimensional coupled ocean-ice models with a space resolution of about 5 km and less to investigate 3-D structure of tides in the subdomains of the BOS, specifically in the areas where shelf waves generate enhanced currents.
- 3) Organize a database of harmonic constituents of tides (sea level, currents, and ice drift) in the BOS. Construct high-accuracy gridded data base (resolution of 10 km, 5 km, and 2 km) for the bathymetry.
- 4) Estimate accuracy of the computed tidal constituents by comparison with field measurements and satellite altimetry (Geosat and Topex/Poseidon missions).
- 5) From the project results, construct database available to the oceanographic community. This base will include tidal sea level, currents and ice motion.

## **APPROACH**

Our approach is to use the high resolution numerical model and available data from ground and satellite stations to delineate regions of enhanced tidal currents. After modeling major features of the tides in BOS, we plan to carry out a detailed analysis of the regions with elevated velocity. For this we shall use data and three-dimensional models. We are will address the following questions:

- 1) What are the major features of the high resolution tides in the BOS domain (sea level oscillations, ellipses of tidal currents and ice drift)?
- 2) What is the contribution of the shelf waves of tidal origin to the generation of high velocity in the BOS region?
- 3) What is the structure of the shelf waves of tidal origin (sea level, currents, ice cover concentration and ridges)?
- 4) What are: a) the pattern of the tidal residual circulation in the BOS region and b) the role of residual currents in the formation of the BOS hydrological regime?
- 5) What are: a) the role of tides in generation of leads, polynyas and zones of high ice ridging in the BOS, and b) the rate of tidal ice production in the BOS?

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- 6) What are: a) the major sources of tidal energy, and b) the pattern of the fluxes of the tidal energy?
- 7) What is the role of tidal mixing in the formation of a space structure of temperature and salinity in the BOS and where are tidal fronts located?

## **TASKS COMPLETED OR TECHNICAL ACCOMPLISHMENTS**

Task #1 has been accomplished by constructing: a) tidal models on a 10-km grid for the entire Bering and Okhotsk Seas, b) local models with resolution of 1.852 km in the regions of enhanced tidal currents and c) a model with a superfine resolution of 617 m for investigation of the residual motion generated by nonlinear interactions

Task #2 is our principal domain of investigation. We have started from a 3-D barotropic model and are now well into a baroclinic 3-D model for investigation of the tidal front over Kashevarov Bank in the Okhotsk Sea.

Task #3 already has been accomplished. The data base for the sea level, current and ice motion from the ground and satellite stations is already in place. The high-accuracy data base for the bathymetry has been constructed on a 1.852-km grid for a few locations in the Sea of Okhotsk (Kuril Straits and Kashevarov Bank), based on Russian bathymetry data. In the Bering Sea region the high accuracy bathymetry data were generated in the region of the Pribilof Islands and Canyon and around St. Matthew Island.

Task #4 is well advanced. The comparison of the field measurements has been done in the Bering and Okhotsk Seas for sea level and velocity. We still need to compare heat flux and ice distribution over regions where enhanced tidal currents occur.

Task #5, i.e., construction of the database available to the oceanographic community will be done in the 1997-98 fiscal year.

## **RESULTS**

In 1997 we concluded investigations of the dynamics of the locally enhanced currents with the help of the 2-D model. The investigations on the 3-D structure are well advanced.

In the Okhotsk Sea the detailed analysis is done at the Kashevarov Bank where diurnal tidal currents up to 4 knots occur. A 3-D model is used to study tidally induced and topographically controlled residual circulation over the bank summit. Tidal mixing seems to be responsible for the observed homogeneous structure over Kashevarov Bank and for a hydrological front in proximity to the bank. To sustain a polynya over Kashevarov Bank a vertical heat flux of 50-100 W m<sup>-2</sup> is necessary. Preliminary estimates show that the source of this vertical heat flux is strong tidal mixing in a 100-m column from the sea surface to the top of the bank.

In the Bering Sea the detailed analysis is performed in the region of Pribilof Islands and Canyon, where a long series of data are available to compare against a high-resolution model. A 2-D model with resolution of 617 m is used to study nonlinear interaction and topographically trapped motion around one of the islands.

A brief illustration is given below of our investigations of the residual currents around St. Paul Island. We start from the large-scale model of the entire Bering Sea with resolution of 9.26 km (Figure 1). The results of computations from this domain serve for construction of the boundary conditions for the domain around Pribilof Island (Figure 1). The resolution applied in the Pribilof Islands domain is close to 1.852 km. The results of computations from the latter domain are applied to establish boundary conditions for the computations around St. Paul with

resolution of 617 m (Figure 1). Due to nonlinear interactions a clockwise residual circulation is established around the island (Figure 2). A comparison of the measured residual motion obtained from the long time series with the residual currents from the tidal model is given in Figure 3. The deflection of the measured currents from the circular pattern is easily associated with the local coastal eddies rendered through the fine-resolution model in Figure 2.

## **IMPACTS FOR SCIENCE & TECHNOLOGY AND/OR APPLICATIONS**

The results of this research have been used for two purposes: a) explanation and prediction of the fate of pollutants in the vicinity of the Pribilof Islands, and b) explanation of ecosystem production at the Pribilof Islands.

Increased fisheries development on St. Paul Island introduces pollutants around the island which stay trapped in this region for a long time due to clockwise currents. EPA uses computed flow pattern around the island to diminish impact of pollution on the ecosystem production.

## **PUBLICATIONS**

Zygmunt Kowalik, BERING SEA TIDE, chapter accepted for a book on Bering Sea to be published by PICKS.

Zygmunt Kowalik & Igor Polyakov, TIDES IN THE SEA OF OKHOTSK, accepted to J. Physical Oceanography

Zygmunt Kowalik and Phyllis Stabeno, TRAPPED MOTION AROUND PRIBILOF ISLANDS, BERING SEA, submitted to J. Geophysical Research.

Zygmunt Kowalik and Igor Polyakov, Shelf waves of tidal origin the Sea of Okhotsk, Transactions, AGU, v.77, n.46, p.379

Figure 1

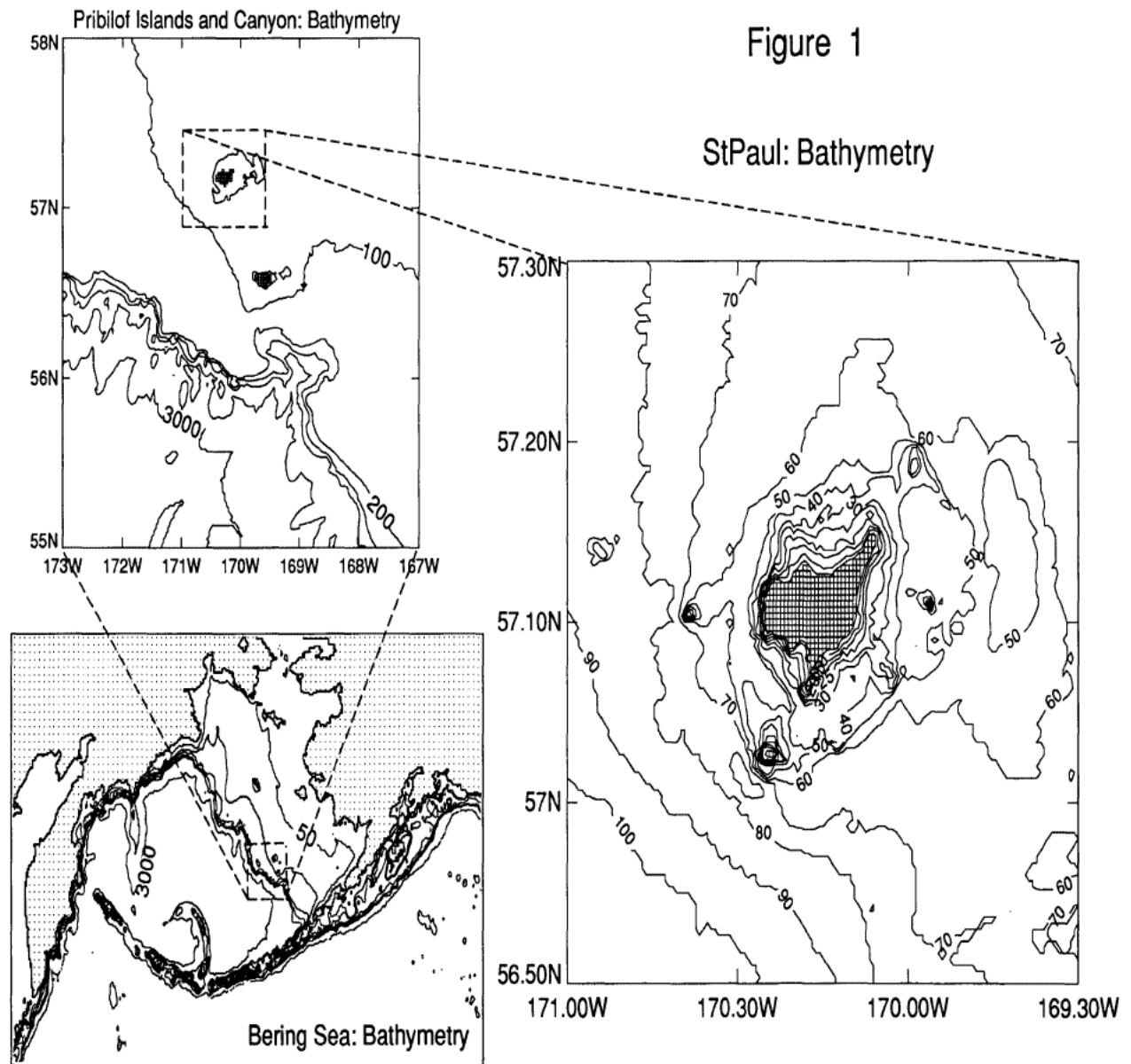


Figure 2: St Paul Island

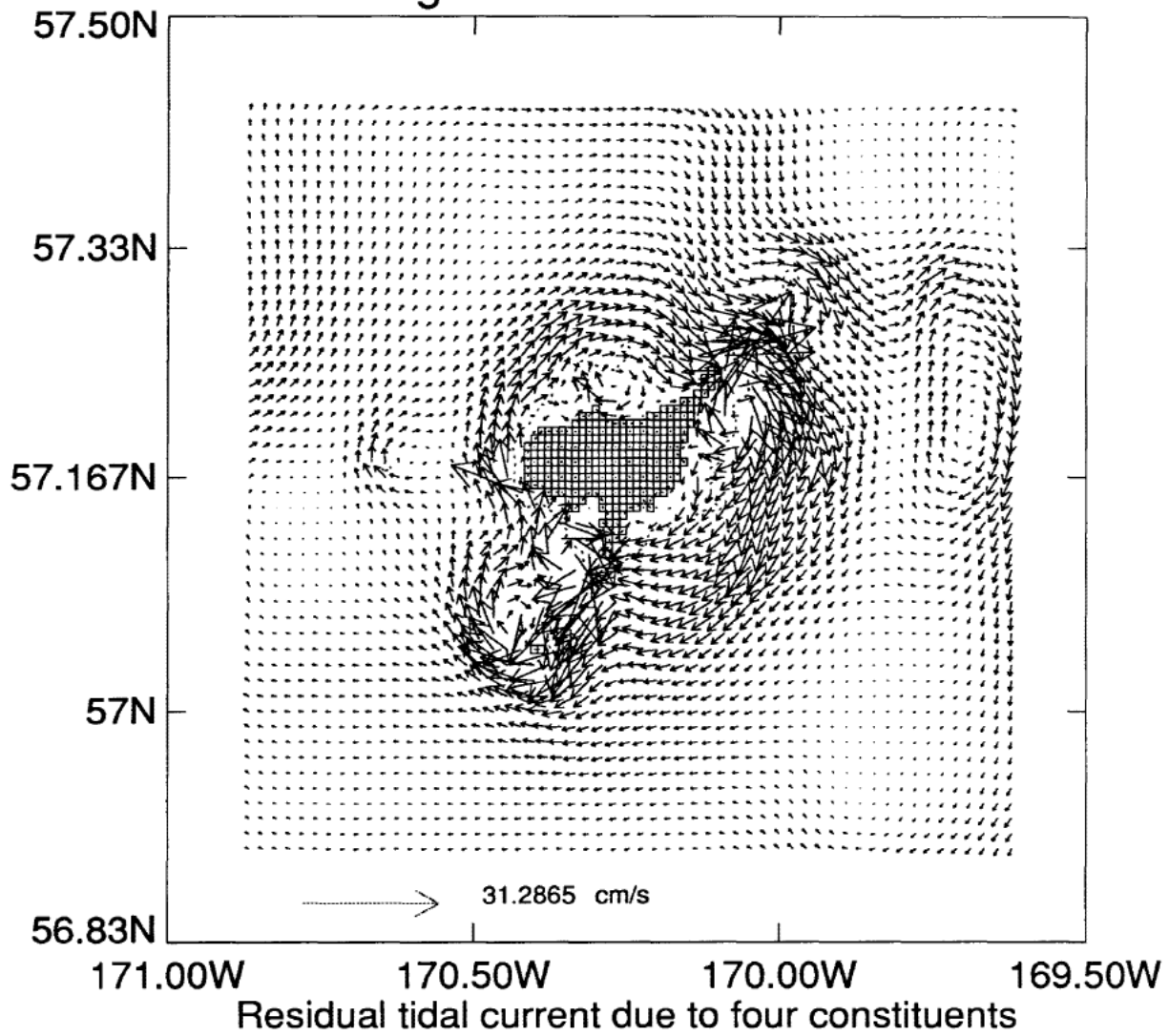
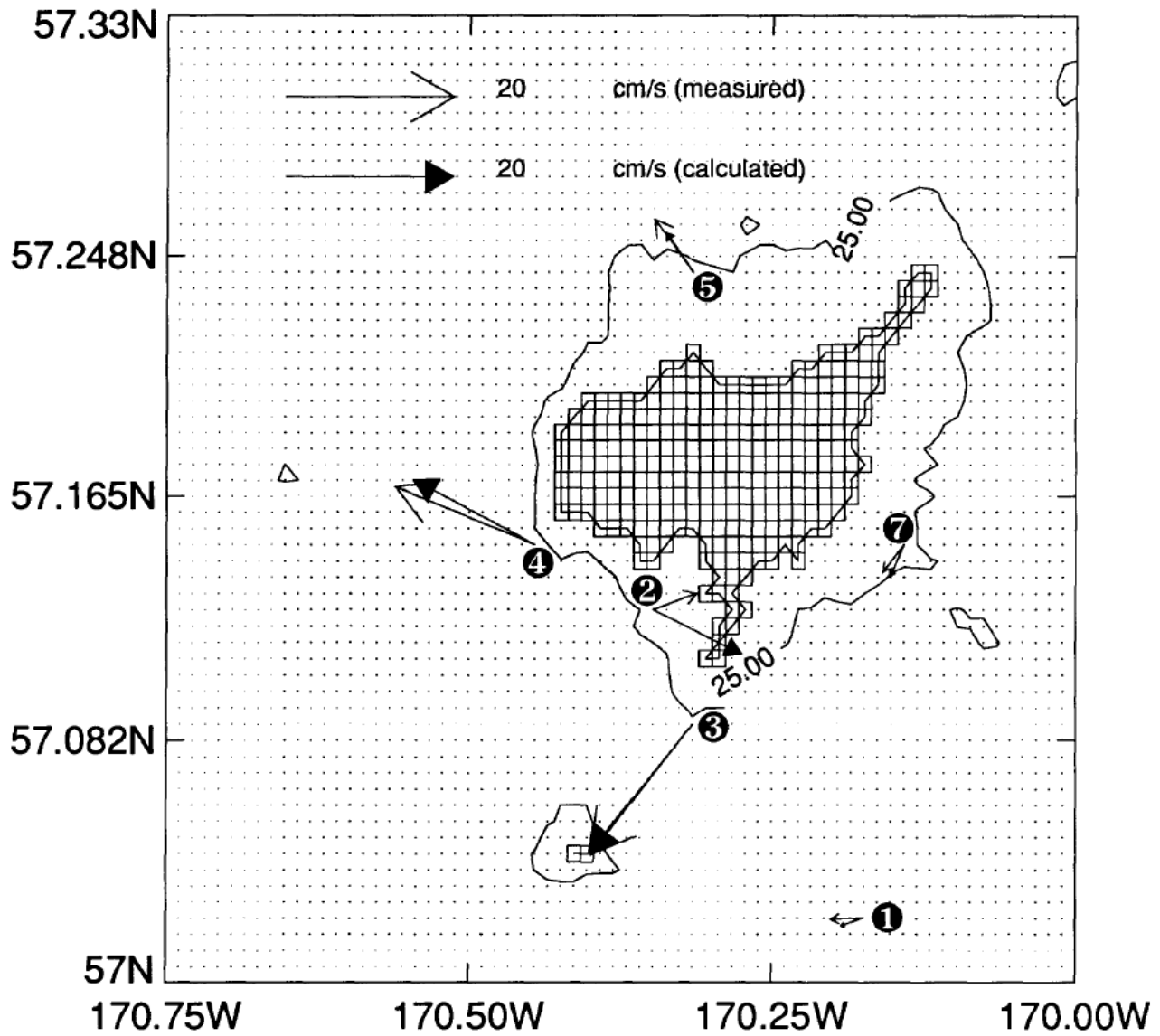


Figure 3



Comparison of measured and computed  
residual currents